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PRICE REDUCTION ON COMPRESSED AIR

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Abstract: *This article will try to offer a way to determine the price of compressed air for a typical industrial system, as well as ways to reduce it. It is well known that compressed air is not quite as inexpensive as it is often thought, the size of the pipe is not always properly chosen, and performance of a selected cylinder is not most advantageous. If you are confronted with these facts, we are very close to the possibility of reducing the cost of compressed air. As a result, any investment may therefore be a multiple return.*

Keywords: – compressed air
– energy saving
– price reduction

1. INTRODUCTION

Towards the experts in the compressed air fields, the cost to produce compressed air varies from 12 to 40 EUR per 1000 m_n^3 [1] which depends on the geographical location. Each manufacturer wants to reduce energy consumption, partly because of production costs, partly because of legal liability.

A study has been done in the European Union which indicated energy consumption for pneumatic systems in some European countries. Table 1. shows that about 10 % of the total industrial electricity consumption in the EU can be attributed to compressed air systems.

Table 1. Annual energy consumption by compressed air systems [2]

COUNTRY	Compressed air systems consumption / TWh	% of industrial electricity consumption
France	12	11
Germany	14	7
Italy	12	11
UK	10	10
Rest of the EU	32	11

As pneumatics has a very low efficiency, one non-optimized compressed air system spends, throughout the ten year period, the majority of the money for maintenance (Figure 2) rather than on capital investments.
It's true there are many potential sources of inefficiency when generating and using compressed air. Following target measures can minimize or prevent losses and significantly reduce energy consumption in pneumatic powered machines:

- minimize the costs for generation of compressed air
- minimize the costs of distribution of compressed air
- minimize the costs in the usage of compressed air
- adopt integration with other utilities, when possible.

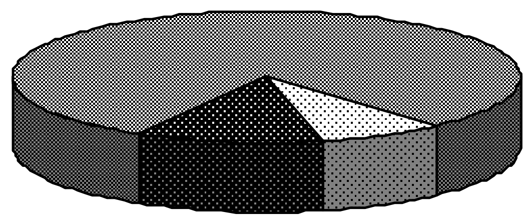

Figure 1. Cost distribution of non-optimized compressed air system

Not so long ago most engineers would take the time to determine the cost of the compressed air required by an actuator. On the contrary, for hydraulic systems, designers must make a calculation for the size of the power unit and the actuators, the size of pipes, pressure drops, etc. Fortunately, the past ten years has recognized the similarities between hydraulic and pneumatic systems. By recognizing the similarities, the perspective is open to the same approach for pneumatic systems. The discussion about compressed air price is a little terrifying for pneumatic components manufacturers, but there is no fear that compressed air will continue to be applied in the industrial sector because it is easily accessible, affordable, clean and less dangerous than hydraulics. As has said T. Dwyer [3] "bigger is not always better". From this perspective, designers have to think about the proper size of the actuator. Over sizing an actuator by one bore size can result in up to a 50 % increase in the cost of the compressed air required. After this step, all components like valves, conductors, fittings, filters, regulators and lubricators will have a better chance of being correctly sized. This principle fits with "Myth 2" — right sizes. And last, "Myth 3" — why use high pressure for retract stroke when it has no effective load. Three main objectives, or so-called "three myths" [1], can be the subject of many improvements.

2. POTENTIAL FOR ENERGY SAVING

2.1. An example for energy/money saving

The cylinder requires a drag out load of a force of 2 kN. The retraction stroke has no effective load. The load has to be moved for 300 mm in 30 cycles per minute. The calculation for compressed air consumption will be made for eight hours per day, five days per week and fifty weeks per year. The compressed air supply pressure is 5,6 bars.

In developing the project, the designer must take eight steps:

Step 1. Sizing of the actuator-cylinder. To size the cylinder for maximum performance (quickest stroke time) the x2 rule is usually used! In this case, a load of 2 kN multiplied by 2, yielding 4 kN.

From:

$$F = A\,p\,, \tag{1}$$

the cross-sectional area needed for the cylinder bore is 7150 mm^2, which suits a cylinder bore of 90 mm. The standard bore is 100 mm, so with the same pressure the piston would move a little slower.

Step 2. The calculation of total volume per cycle. If we assume the use of a differential cylinder with a standard rod diameter of 50 mm, the extended volume is:

$$V = A s\ , \tag{2}$$

and that is $2{,}36 \cdot 10^6$ mm^3. For retraction, the volume is $2{,}2 \cdot 10^6$ mm^3. Therefore, total volume per cycle is $4{,}56 \cdot 10^6$ mm^3.

If we choose a cylinder of one degree higher, its total volume would be $7{,}12 \cdot 10^6$ mm^3. Total volume is increased for 56%!

Step 3. Calculation of the total volume per minute. We must multiply volume per cycle with number of cycles, which gives 136,8 l/min.

Step 4. Calculating the compression ratio:

$$r = \frac{p_{abs}}{p_{atm}}. \quad (3)$$

The compression ratio is 6,6.

Step 5. The amount of the intake air is $136{,}8 \cdot 6{,}6 \approx 903$ l/min.

Step 6. The actual required compressor power for the assumed efficiency of 50% is about 12 kW.

Step 7. Carrying out the intake air per year, that is 903 l/min x 60 min/hour x 8 hour/day x 5 days/week x 50 weeks/year = 108 360 m_n^3.

Step 8. If we take the average price for 1000 m_n^3, this gives 26 x 108,36 ≅ 2800 EUR.

Let's consider another approach to the problem. If we go back to step 2, and for the return stroke instead of a pressure 5,6 bar we choose a pressure of 1,5 bar, the consumption of the compressed air will be 632 l / min. That makes the compressed air consumption for 30 % less than if we use a greater pressure in the return stroke.

By changing the pressure on the return stroke to 1,5 bar, the price for the compressed air consumption would be reduced to 1960 EUR. If we add a pressure regulator, cost recovery can be expected after about two months.

For a cylinder one degree higher, the cost will be about 4400 EUR.

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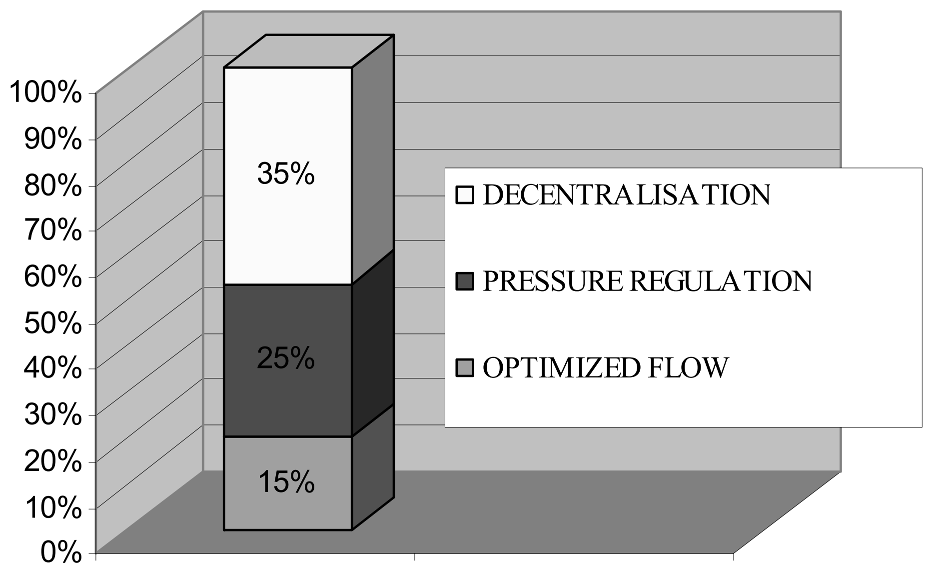

Figure 2. The main sources of energy saving

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2.2. Smart regulation

In many applications cylinders either push or pull a load, but not both. Nevertheless, most often machines use the same pressure for both extend and retract strokes, which is extremely inefficient. In our example it is very clearly explained. Supplying the right pressure for each task by using a pressure regulator can lower energy consumption by more than 25 %. Today, the so-called "smart" controllers that combine digital control electronics with proportional valves are a very effective way of controlling air consumption based on the actual needs of technological processes. They constantly compare the actual pressure value with a preset pressure value.

2.3. Decentralized air supply

The centralized control valve is a handicap because there are long lines, which require lots of energy. Manufacturers now offer small, decentralized valves and controls, which focuses pneumatic functions in on the point of use. Valves can be mounted directly on the cylinders without the long pipeline from the control cabinet to the actuator. Valve/actuator units can reduce tubing connections by 50 % and cut energy use by 35 %. Decentralized systems can also yield faster response times and higher cycle frequencies.

2.4. Avoiding leaks

Any pneumatic system can save energy. There are two possible sources of leaks, certain types of valves and damaged seals. Lapped-spool valves with metal seals have an inherent constant internal leakage, so it would be effective to substitute them with comparable valves with soft seals. Another source of leaks is industrial seals attacked by chemicals in the air system. Consequently, standard Buna seals, which are very much degradable, are replaced with HNBR, Viton, PTFE or polyurethane.

2.5. Control for on/off valves

In most installations, the air supply of machines that are not currently in use does not end, and the employment of staff who will do just that is an additional cost. Some subsystems may require compressed air even when the machine is turned off, such as air bearings, measuring instruments and systems for cleaning. Therefore, these functions can satisfy the lower air pressure or short-term use of high pressures.

For machines that do not work continuously, an automatic air-reduction control reduces the supply pressure and air consumption when the plant is not operating. Also, the system can be manually managed, if a higher pressure at the time of stoppage is needed.

3. PERMANENT CONTROL OF AIR CONSUMPTION

Modern air-preparation units are available with an integrated air-volume sensor. The sensor emits an electrical pulse each time a specific volume of pressed air has passed through the air-preparation package. The electrical pulse signals can be totalled by the controller and therefore actual air consumption (and energy cost) can be calculated for the machine over a period of time. Also, it can be predicted that the user is informed about the increased consumption of air, which may indicate the occurrence of a leak or an unplanned increase in operating pressure of the machine. The real life cost of leakage and over-pressurization can be counted as well as the cost saving from correcting these problems.

4. CONCLUSION

Industrial equipment that generates or uses compressed air has many opportunities for reducing energy costs. The main feature is in the proper sizing of actuators, pipes and fittings, the use of "smart regulation" of air pressure, and the modern construction of valves mounted on the actuator. Such equipment can control a leak in the plant and can shut off the air when the machine is not working. Generally speaking, opportunities for saving energy and saving money are multiple. If we take into account the data from Figure 2 and the actual cost of the compressed air, the price can be reduced between 3 and 10 EUR per 1000 m_n^3. If we go back to the numerical example in this article, for only one actuator, the annual price of compressed air consumption would not be 2800 but 700 EUR.

5. LIST OF SYMBOLS

cylinder cross section	A, m^2
piston force	F, N
air supply pressure	p, MPa
absolute pressure	p_{abs}, MPa
atmospheric pressure	p_{atm}, MPa
pressure ratio	r, -
cylinder piston stroke	s, mm
cylinder chamber volume	V, mm^3

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Technical note

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